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New Coincident, Leading and Recession Indexes for the Canadian Economy: An Application of the Stock and Watson Methodology

by

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Abstract

Using modern econometric techniques, Stock and Watson (1989) developed a new system of composite indexes of coincident and leading economic indicators, as well as a recession index for the United States. We apply this approach to build coincident and leading economic indexes for the Canadian economy. The composite coincident economic index (CEI) is based on an econometric model in which the "state of the economy" is an unobserved variable, which is common to several macroeconomic variables. The model is based on the fact that the fluctuations in these variables share a common element, which can be estimated. The approach to the construction of the composite leading economic index (LEI) is also different from the traditional apprcach. Rather than constructing a composite index on the basis of a weighted average of leading indicators, we use past changes in the CEI, as well as other variables that have historically led the business cycle, to forecast the change in the CEI over the coming three or six months. If the coincident index truly reflects the state of the economy, then a good forecast of this coincident index should make a good leading index. We also build a recession index for the Canadian economy. Unlike Stock and Watson, who used a rather complicated and tedious procedure, our recession index is the forecast probability that the economy will be in a recession in the coming three or six months based on logit models, using data available through the month of its construction and the constructed LEI.

Résumé

Stock et Watson (1989) ont développé un nouvel ensemble d'indices composites coïncident et avancé, ainsi qu'un indice de récession pour les États-Unis en utilisant des techniques économétriques modernes. Nous appliquons cette approche pour construire des indices coïncident et avancé pour l'économie canadienne. L'indice économique coïncident (CEI) est basé sur un modèle économétrique dans lequel « l'état de l'économie » est une variable non observable commune a plusieurs variables macro-économiques. Le modèle est basé sur le fait que les fluctuations de ces variables

partagent un élément commun qui peut être estimé. L'approche pour la construction de l'indice économique avancé (LEI) est également différente de la méthode traditionnelle. Plutôt que de construire un indice composite sur la base d'une moyenne pondérée de plusieurs indicateurs avancés, nous utilisons les variations passées du CEI ainsi que d'autres variables qui ont historiquement devancé le cycle économique pour prévoir les variations du CEI pour les trois ou six mois à venir. Si l'indice économique coïncident reflète réellement l'état de l'économie, alors une bonne prévision de cet indice devrait produire un bon indice économique avancé. Nous construisons également un indice de récession pour l'économie canadienne. Contrairement à Stock et Watson qui utilisent une procédure relativement lourde et complexe, notre indice de récession est une prévision de la probabilité que l'économie se retrouve en récession pour les trois ou six mois à venir, estimée à partir de modèles logit et en utilisant les données disponibles jusqu'au mois de sa construction.

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1. INTRODUCTION

Cyclical indicators receive regular press coverage and attention from economists because they tend to provide additional information on the direction of a business cycle. Cyclical indicators originate from the work of W.C. Mitchell and A.F. Burns in the 1920s and 1930s. These authors examined a large number of economic time series to determine if their cyclical turning points led, coincided, or lagged the turning points in the U.S. business cycle. Thus, they were able to classify the series as leading, coincident or lagging indicators. The NBER economists, notably Julius Shiskin and Geoffrey H. Moore, conducted further research in this area in the 1950s and 1960s. These authors combined the best series into coincident, leading, and lagging economic indexes. In November 1968, the composites indexes were released to the public for the first time in the Business Conditions Digest published by the U.S. Bureau of the Census. Thereafter, the development of the U.S. index spurred the development of indexes by public organizations throughout the world, notably the OECD, Statistics Canada and Finance Canada.

In the 1970s and 1980s, cyclical indexes released by public organizations underwent many modifications to reflect changes in the economy, to take into account new data availability, to update the weighting scheme, and to incorporate research results by economists, notably on the leading relationship of the yield curve. However, the selection and weighting processes remained unchanged from the NBER cyclical indicator approach until 1989, when Stock and Watson provided an alternative to the NBER approach by constructing cyclical indicators using modern econometric techniques.

The goal of this paper is to create monthly coincident and leading economic indexes for the Canadian economy using the Stock and Watson methodology. The paper also proposes a recession index, derived from the constructed leading index. The paper is organized as follows. The first two sections explain how the coincident and leading economic indexes are built and assess their respective statistical relationship with the Canadian business cycle. The third section presents a recession index. The main conclusions of the paper are reported in the last section.

2. COMPOSITE COINCIDENT ECONOMIC INDEX

2.1 Definition

The term "business cycle" commonly refers to co-movements in a broad range of macroeconomic activity such as output, employment and retail sales. As in Stock and Watson, the coincident economic index (CEI) represents the unobservable "state of the economy" and is coincident with the business cycle.[1] The co-movements of observed coincident economic variables at all leads and lags arise solely from movements in this unobserved "state of the economy".

2.2 Potential coincident variables

To apply the Stock and Watson method to construct a Canadian coincident economic index, we first need a series of economic variables with observed co-movement. We considered a number of four-, five- and six-variable combinations from a pool of eleven possible coincident variables: total employment, total employment in goods sector, hours worked in the manufacturing sector, real manufacturing shipments, real labour income, real wages and salaries, real retail sales, total and urban housing starts, U.S. Conference Board's coincident economic index for the U.S. economy, and the overall index of U.S. manufacturing activity from the Institute for Supply Management (ISM) – formerly NAPM. We then evaluate each obtained experimental coincident economic index by examining the model specification and the correlations between the index and monthly real GDP at factor cost and quarterly real GDP at market price. We end up with a set of five potential coincident variables, which are listed in Table 2.1 (next page).

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[1] The Stock and Watson coincident economic index for the United States is a weighted average of four broad monthly measures of the U.S. economic activity: the industrial production, the total real personal income less transfer payments, the total real manufacturing and trade sales, and the total hours-worked in non-farm establishments.

Table 2.1 Potential Coincident Economic Variables

Name	Description
TE	Total employment
MS	Real manufacturing shipments
RS	Real retail sales
HS	Total housing starts
USCI	U.S. coincident economic index from the U.S. Conference Board

2.3 Procedure

We follow the well established Stock and Watson (1989) dynamic factor model of coincident variables to estimate the unobserved single index of coincident indicators. The structure of the model used here is:

$$\Delta X_t = \beta + \gamma(L)\Delta S_t + \mu_t, \tag{2.1}$$

$$D(L)\mu_t = \varepsilon_t, \tag{2.2}$$

$$\phi(L)\Delta S_t = \delta + \eta_t, \tag{2.3}$$

$$\Delta C_t = a + b\Delta S_t, \tag{2.4}$$

$$CEI_t = 100 * \exp(C_t) / A, \text{ where } A \text{ is the average of } \exp(C_t) \text{ in 1992.} \tag{2.5}$$

where X is a vector of the logarithm of observed coincident economic variables, S_t represents the logarithm of the state of the economy at time t, L denotes the lag operator, and $\phi(L)$, $\gamma(L)$ and $D(L)$ are respectively scalar, vector and matrix lag polynomials. The error term μ_t is serially correlated and its dynamics are specified by (2.2), while the error terms (ε_t, η_t) are assumed to be serially uncorrelated with a zero

mean and a diagonal covariance matrix Σ. C_t is the de-normalized state of the economy variable S_t, and CEI is the constructed coincident economic index (CEI).

The system (2.1)-(2.3) is a form of the state-space model, and the parameters of the system (2.1)-(2.3) and the unobserved state of the economy can be estimated using a Kalman filter[2]. Following the standard procedure of Stock and Watson, each coincident economic variable in the vector X is first-differenced and normalized by subtracting its mean difference and then dividing by the standard deviation of its difference. This identifies $\beta = 0$ and $\delta = 0$ for the estimation. However, the normalization and the identification strategy used here yield an estimator of the state variable ΔS_t with a zero mean and a unit variance. It must be de-normalized and de-logged to form the coincident economic index. The de-normalization (C_t) is given in equation (2.4)[3]. Equation (2.5) de-logs the coincident economic index and then normalizes it so that its average value over the twelve months of 1992 is equal to 100.

2.4 Results

The specification of the system (2.1)-(2.3) and the estimated parameters (with the sample from 1966:02 to 2001:06) are reported in Table 2.2 (page 5). The proposed monthly coincident economic index is plotted in Figure 2.1 (page 6). We also plot the quarterly average of the proposed coincident economic index against the quarterly real Canadian GDP at market prices (normalized so that 1992 = 100) in Figure 2.2.

The constructed CEI represents the common state of the economy. It reflects only the pattern of the economic situation rather than the size of the economy or the magnitude of the growth of the economy. Therefore, it tells whether the economy is in expansion or in contraction, but it cannot be used to predict the GDP growth rate.

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[2] See Y. Liu (2001) for an introduction to the application of state-space models and a Kalman filter.

[3] For the detailed procedure of this de-normalization and estimation of the parameters a and b, please see Clayton-Matthews and Stock (1998), and Kim and Nelson (1999).

Table 2.2 Maximum Likelihood Estimation of the Factor Model (2.1)-(2.3)

A. Measurement Equations:

$$\Delta MS_t = 0.286\Delta S_t + \mu_t^{MS}$$
(0.040)

$$\Delta RS_t = 0.220\Delta S_t + \mu_t^{RS}$$
(0.036)

$$\Delta HS_t = 0.125\Delta S_t + \mu_t^{HS}$$
(0.046)

$$\Delta USCI_t = 0.623\Delta S_t + \mu_t^{USCI}$$
(0.072)

$$^{*}\Delta TE_t = 0.155\Delta S_t + 0.173\Delta S_{t-1} + 0.229\Delta S_{t-2} + \mu_t^{TE}$$
(0.060) (0.066) (0.058)

B. Transition Equations:

$$\Delta S_t = 0.264\Delta S_{t-1} + 0.257\Delta S_{t-2} + \eta_t;\ \sigma_\eta = 1.0 \text{ (normalized)}$$
(0.088) (0.082)

$$\mu_t^{MS} = -0.697\mu_{t-1}^{MS} - 0.363\mu_{t-2}^{MS} + \varepsilon_t^{MS};\ \sigma_{\varepsilon^{MS}} = 0.752$$
(0.051) (0.050) (0.031)

$$\mu_t^{RS} = -0.517\mu_{t-1}^{RS} - 0.365\mu_{t-2}^{RS} + \varepsilon_t^{RS};\ \sigma_{\varepsilon^{RS}} = 0.815$$
(0.046) (0.046) (0.030)

$$\mu_t^{HS} = -0.213\mu_{t-1}^{HS} - 0.109\mu_{t-2}^{HS} + \varepsilon_t^{HS};\ \sigma_{\varepsilon^{HS}} = 0.968$$
(0.049) (0.049) (0.034)

$$\mu_t^{USCI} = 0.317\mu_{t-1}^{USCI} + 0.220\mu_{t-2}^{USCI} + \varepsilon_t^{USCI};\ \sigma_{\varepsilon^{USCI}} = 0.631$$
(0.091) (0.079) (0.066)

$$\mu_t^{TE} = -0.190\mu_{t-1}^{TE} + 0.107\mu_{t-2}^{TE} + \varepsilon_t^{TE};\ \sigma_{\varepsilon^{TE}} = 0.861$$
(0.063) (0.059) (0.035)

Note: the numbers in brackets are standard deviations.

* The inclusion of two lagged states reflects the fact that employment is a weak lagging variable.

Figure 2.1 The Proposed Coincident Economic Index (1966M02-2001M06)

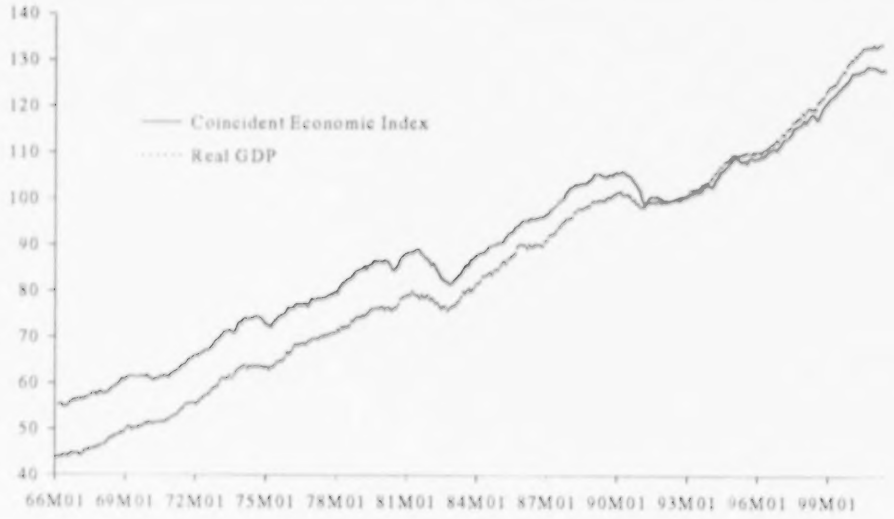

Figure 2.2 The Proposed Coincident Economic Index (quarterly average) versus Real Canadian GDP (1966Q2-2001Q2)

Next, we apply a standard Markov-switching Autoregressive (MSAR) model of Hamilton (1989) to investigate the business cycle manifested by our proposed coincident economic index. The model has the form:

$$y_t - m_{s_t} = \phi_1(y_{t-1} - m_{s_{t-1}}) + \ldots + \phi_p(y_{t-p} - m_{s_{t-p}}) + \sigma\varepsilon_t,$$

where y_t is the growth of the CEI; s_t is the stage of the economic cycle and takes two discrete values representing two regimes: $s_t = 0$ if period t is in recession, and $s_t = 1$ if period t is in expansion; $m_{s_t} = m_0 + (m_1 - m_0)s_t$ is the mean of the process y_t, which depends on s_t, the stage of the economic cycle: $m_{s_t} = m_0$ if $s_t = 0$, while $m_{s_t} = m_1$ if $s_t = 1$.

We assume that the regime of the economy, s_t, is governed by a first-order Markov chain with the following transition probabilities:

$$P(s_t = j \mid s_{t-1} = i, s_{t-2} = k, \ldots) = P(s_t = j \mid s_{t-1} = i) = p_{ij}, \text{ for } i, j \in \{0, 1\}.$$

This MSAR model can be used to estimate the probability of the regime (recession or expansion) of the economy in each time period. We apply an MSAR(1) model[4] (namely the order of AR process $p = 1$) to the growth rates of our proposed coincident economic index. The estimated probabilities of recession are shown in Figure 2.3.

According to these estimated probabilities and the rule suggesting that a recession is called when we get at least six months in a row with an inferred probability greater than 50%, the Canadian economy experienced three recessions in the past three decades which are identified as 1974:10-75:03, 1981:07-82:10, and 1990:04-91:03. When we relax the rule to a minimum of four consecutive months with an inferred probability greater than

[4] Hamilton's standard model has been criticized (see Hansen (1992)) and extended in many directions to address different issues. For example, Filardo (1994), Durland and McCurdy (1994) and Layton (1998) assume time-dependent transition probabilities to address the duration of business cycles. Gray (1996), Bekaert, Hodrick and Marshall (1997), Ang and Bekaert (1998), and Dahlquist and Gray (2000) all assume both time-dependent transition probabilities and time-dependent variance (conditional heteroscadasticity) in analyzing interest rates or term structures. However, when it comes to dating business cycles, the standard Hamilton model with lower order AR process (say AR(1) or AR(0)) seems do better jobs, see Lahiri and Wang (1994) and Ahrens (1999). Hans-Martin Krolzig has successfully applied standard Hamilton models to date business cycles in various countries.

50%, we get a fourth recession: 1980:03-80:06. These dates are very close to the recession dates identified by Statistics Canada (see Cross (1996)). In terms of quarters, our dates are identical to Cross's recession dates (see table 2.3). Therefore, our recession dates obtained here are used to build the recession index later.

Figure 2.3 Recession Probabilities of Coincident Index (estimated by MSAR(1)) (1966M03-2001M06)

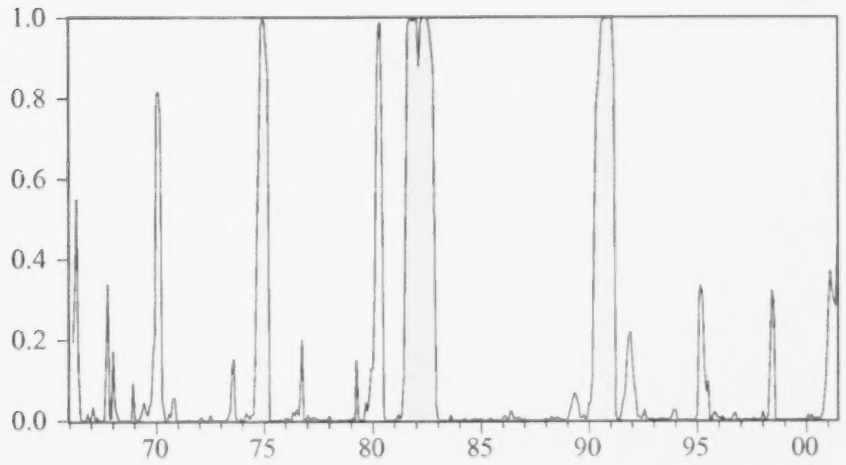

Table 2.3 Comparison of Recession Dates - This paper versus Cross (1996)

Monthly Recession Dates		Quarterly Recession Dates	
This paper	Cross	This paper	Cross: Recession dates for GDP
1974:10-75:03	1975:01-75:03	1974:4-75:1	none
1980:03-80:06	1980:02-80:06	1980:2	1980:2
1981:07-82:10	1981:07-82:10	1981:3-82:4	1981:3-82:4
1990:04-91:03	1990:04-92:04	1990:2-91:1	1990:2-91:1

3. COMPOSITE LEADING ECONOMIC INDEX

3.1 Definition

Stock and Watson's approach to the construction of a leading economic index (LEI) is far different from the traditional NBER approach. Rather than constructing a leading economic index on the basis of a weighted average of individual leading economic variables, Stock and Watson use past changes in their coincident economic index as well as other variables that have historically led the business cycle to forecast future changes in their coincident economic index. If the coincident index truly reflects the state of the economy, then a good forecast of this coincident index should make a good leading index.[5] This is different than a leading economic index built with the traditional indicator approach where the index is expressed in levels and is a weighted average of individual leading variables, and is most often used to signal in advance cyclical turning points in the business cycle.

3.2 Potential leading variables

We considered 68 potential leading variables from different sectors and markets of the economy: the consumption sector, the residential and non-residential sectors, the monetary, financial, and exchange rate markets, the foreign market, the government sector, and the labour market.

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[5] The Stock and Watson leading economic index for the United States includes seven variables: the long term/short term Treasury bond yield spread, the private-public interest rate spread, the change in the 10-year Treasury bond yield, the trade-weighted nominal exchange rate, the part-time work in non-agricultural industries, the housing authorizations and the manufacturers' unfilled orders for durable goods industries. Overt the 1960s through the 1980s, their leading index predicted the same number of recessions as the traditional index formerly released by the U.S. Department of Commerce and now by the U.S. Conference Board, but produced considerably fewer false signals. However, the Stock and Watson didn't forecast the 1991-1992 recession as well as the 2001 recessions.

Evaluation and selection

The potential leading variables from all sectors and markets were evaluated by examining their leading relationship to the coincident economic index. We used the following approach:

- First, we visually inspect the historical movement of each leading series to detect the relationship with the cyclical turning points of the coincident economic index.
- Second, we examine the simple correlation of each leading variable with the coincident economic index over the entire sample. A potential leading variable should have higher correlation with the reference series at a lead of one or greater.
- Third, we assess the ability of each leading series to Granger-cause the coincident economic index.
- Fourth, we regress each leading variable on the coincident economic index and get the adjusted R^2. A potential leading variable should have higher fit of the regression at a lead of one or greater.
- Finally, we use Markov-switching models on each leading series to compare and assess the leading pattern in the cycle chronologies with the coincident economic index. See Appendix A for more details on the Markov-switching models.

We end up with a set of twenty-six potential leading variables. See Table 3.1 (page 11) for a list and a description of the selected candidate variables.

3.3 Procedure

Stock and Watson use the Vector Autoregressive (VAR) methodology for this forecast of the coincident index. The authors estimate a VAR but they only use the equation linking the change in the coincident index with the other variables in the system to make the forecast. We will also focus on this first equation. We use the following approach to construct the leading economic index for the Canadian economy.

Table 3.1 Selected potential leading economic variables

Name	Description
HWI	Help wanted index
RBP	Residential building permits
NRBP	Non-residential building permits
CBLUS	U.S. leading economic index from U.S. Conference Board
FLUS	U.S. leading economic index from Finance Canada
CBCEUS	U.S. index of consumer expectations from U.S Conference Board
OLUS	U.S. leading economic index from OECD
OLEU	Europe leading economic index from OECD
NER	Nominal exchange rate
RER	Real exchange rate
FCPI	Nominal index of commodity prices from Finance Canada (in U.S. dollars)
FRCPI	Real index of commodity prices from Finance Canada (in U.S. dollars)
RM1	Gross M1 in real terms (deflated by total consumer price index)
MCI	Monetary conditions index from the Bank of Canada
YCA	Yield curve – 10 year bond *minus* 3 month corporate paper
YCB	Yield curve – 10 year bond *minus* 1-3 year bond
YCC	Yield curve – 1-3 year bond *minus* 3 month corporate paper
YCD	Yield curve – 1-3 year bond *minus* 3 month Treasury bills
YCE	Yield curve – 3 month Treasury bills *minus* 3 month corporate paper
USYCA	U.S. Yield curve – 10 year bond *minus* Fed funds rate
USYCB	U.S. Yield curve – 3 month Treasury bills *minus* 3 month corporate paper
RTSE	Real TSE 300 aggregate index (deflated by total consumer price index)
RSP500	Real S&P 500 stock market index (deflated by total consumer price index)
CC	Index of consumer confidence from the Conference Board of Canada
FBSGDP	Federal balance as a share of GDP
UPSGDP	Undistributed profits as a share of GDP

Equation 3.1 shows how the growth rate of the coincident economic index is connected with the leading economic variables with k months in the forecast horizon:

$$\Delta C_t^{t+k} = \sum_{i=0}^{p_0} \beta_i \Delta C_{t-i} + \sum_{i=0}^{p_1} \delta_i^1 Y_{t-i}^1 + \sum_{i=0}^{p_2} \delta_i^2 Y_{t-i}^2 + \ldots + \sum_{i=0}^{p_n} \delta_i^n Y_{t-i}^n + e_t \qquad (3.1)$$

where $\Delta C_t^{t+k} = (1200/k) * [(C_{t+k}/C_t) - 1]$ and $\Delta C_{t-i} = (1200/k) * [(C_{t-i}/C_{t-i-k}) - 1]$ are the appropriate transformations of the coincident economic index. Y_t^j, for j = 1 to n, represents each of the leading variables at time t. Like the coincident economic index, all the variables are transformed to be stationary as applicable. The different numbers of lags for each series (p_j, for j = 0 to n) are chosen on the basis of the Akaike criterion for full-sample estimation and in order to ensure that the residuals are white noise.[6] The search was restricted to models with 3, 6, 9 and 12 lags of the variables for computational reasons.

Furthermore, we restricted the forecast horizon k to 3 and 6 months.[7] We estimate the model over the period from 1973:01 to 1983:12, and we calculate $LEI_t = \Delta \hat{C}_t^{t+k}$ for 1983:12+k using the estimated coefficients.[8] We then proceed with the estimation by including one more period, until 1984:01, and we calculate LEI_t for the 1984:01+k period, and so on until the end of the sample, which is 2001:06.

Stock and Watson do not mention any detailed procedure to choose their base model. Our procedure to select the leading economic variables to include in the equation 3.1 was very simple. Starting with a base case including only the coincident economic index on the right-hand side, indexes were constructed by including twelve lags of each of the candidate trial variables in the k-step ahead regressions. Based on the fit of the regression and on the forecast performance, we set the first leading variable as the one with the best

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[6] We also used the Schwarz criterion to choose the appropriate numbers of lags and it appeared that the results were relatively unchanged.

[7] We tried a forecast horizon of 1 month of the monthly growth rate of the coincident index. Given that the coincident index contains considerable high frequency noise, the performance of the forecast was very poor. Furthermore, we believe that 12 months ahead is too long. Thus, forecast horizons of 3 and 6 months seemed reasonable.

[8] The sample for the leading index is shorter than for the coincident index given that we have potential leading indicators starting only in 1973. We had to cut the sample to evaluate all the candidate variables on the same basis.

statistics. The criterions used for evaluation are the adjusted R^2, the root mean squared error (RMSE), the mean absolute error (MAE) and the U-Theil coefficient. Then, we repeat the same process with the new base case including appropriate number of lags in the coincident index and the first leading variable and twelve lags of each of the remaining potential variables. After which, we choose the second leading variables, re-estimate the new base case and so on until the forecast performance cannot be improved anymore.

3.4 Results

As mentioned earlier, we choose to concentrate our attention on two models: a three-month ahead forecast of the three-month growth rate in the CEI and a six-month ahead forecast of the six-month growth rate in the CEI. Both models were constructed with the same procedure explained in the previous subsection.

Three-month forecast horizon

The leading economic index estimated with a forecast horizon of three months (LEI-3) includes four variables in addition to the coincident economic index: the help wanted index, the short-term yield curve, the U.S. leading economic index from the U.S. Conference Board and the non-residential building permits. The calculations resulted in a model with twelve lags on the short-term yield curve and three lags on the remaining variables. The three-month growth rate in the CEI and the LEI-3 are plotted in Figure 3.1 (page 14), which also provides a description of the model and the key statistics relative to its forecast performance. We can see that the fit is very good (0.618) and the errors are relatively small on average. Furthermore, the RMSE, the MAE, and the U-Theil coefficient suggest that the forecast of the three-month growth rate in the coincident economic index could not be improved anymore with additional variables as shown in Table 3.2 (page 15).[9]

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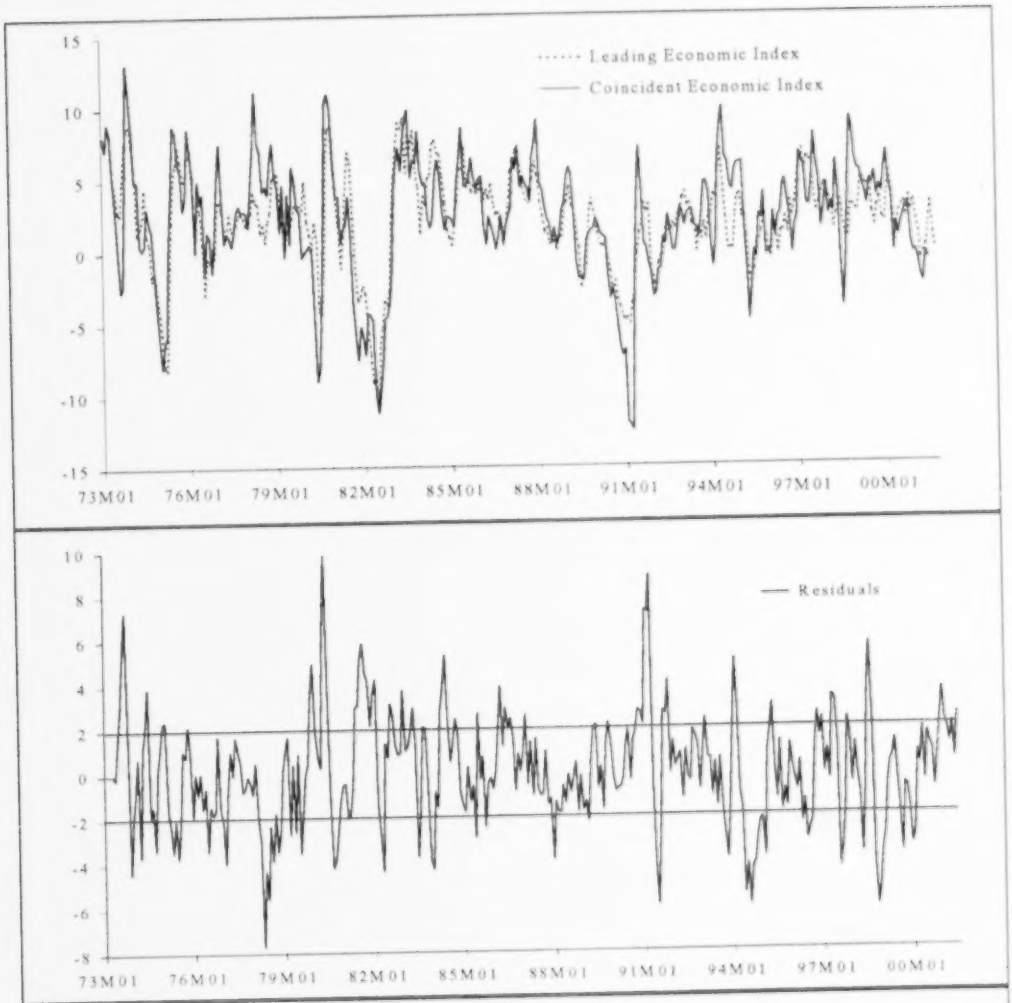
[9] As suggested by Stock and Watson, we also tried to smooth the noisy series. We used the same filter: $(1+2L^2+2L^3+L^4)/6$. The performance of the forecast was not improved. We reached the same conclusion for the six-month ahead forecast.

Figure 3.1 Three-month growth rate in the CEI and the LEI-3



The model:

$$\Delta C_t^{t+3} = \sum_{i=0}^{3} \beta_i \Delta C_{t-i} + \sum_{i=0}^{3} \delta_i^1 HWI_{t-i} + \sum_{i=0}^{12} \delta_i^2 YCE_{t-i} + \sum_{i=0}^{3} \delta_i^3 CBLUS_{t-i}$$

$$+ \sum_{i=0}^{3} \delta_i^4 NRBP_{t-i} + e_t$$

Full sample adjusted R^2: 0.618;
Out-of-sample RMSE: 2.328; MAE: 1.782; U-Theil: 0.312

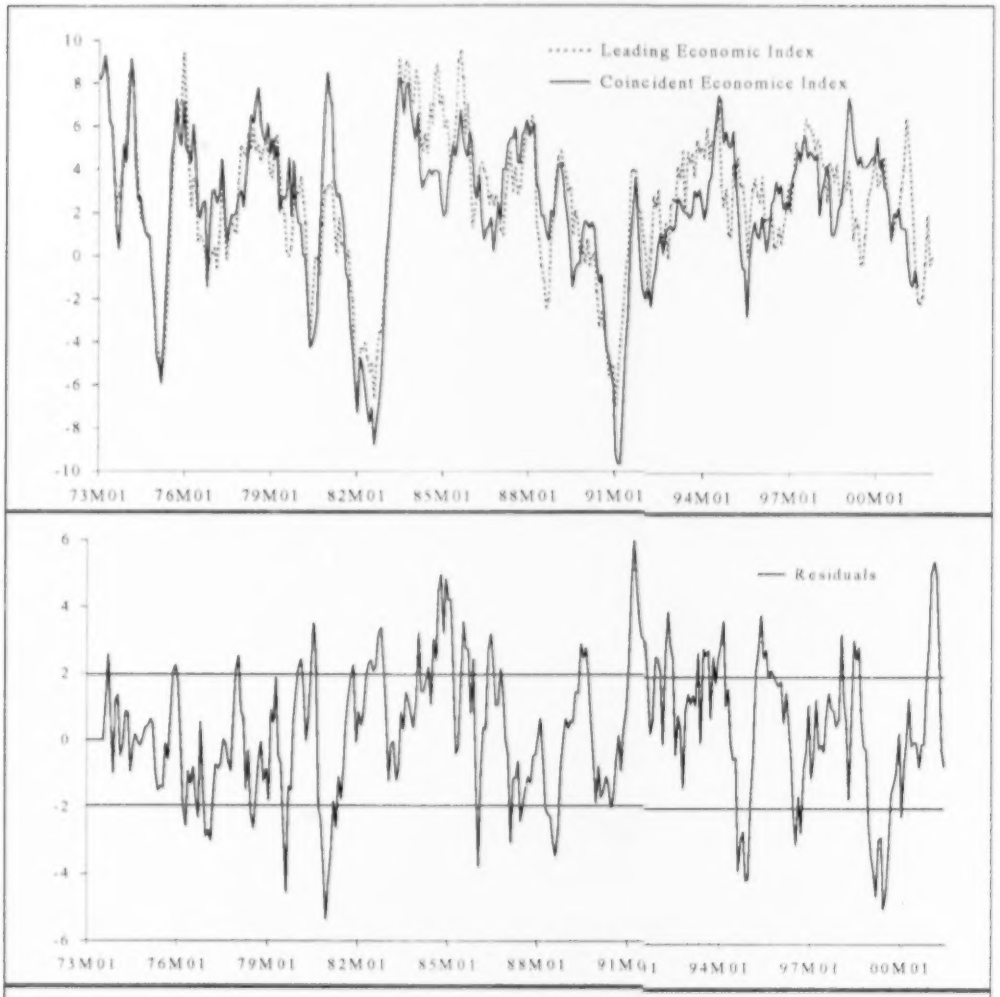
Table 3.2 Effect of including additional variables in the LEI-3

Variables	*p-value* 6 lags	12 lags	Adj. R^2	RMSE	MAE	U-Theil
Base model	---	---	**0.618**	**2.328**	**1.782**	**0.312**
Additional variables:						
RBP	0.632	0.719	0.617	2.410	1.824	0.321
FLUS	0.959	0.326	0.619	2.478	1.869	0.325
CBCEUS	0.786	0.158	0.622	2.451	1.877	0.321
OLUS	0.261	0.689	0.630	2.419	1.837	0.325
OLEU	0.527	0.880	0.621	2.401	1.826	0.317
NER	0.791	0.160	0.613	2.483	1.887	0.329
RER	0.998	0.363	0.612	2.467	1.876	0.328
FCPI	0.205	0.083	0.638	2.507	1.980	0.330
FRCPI	0.226	0.062	0.639	2.507	1.989	0.330
RM1	0.310	0.992	0.617	2.652	2.073	0.333
MCI	0.952	0.512	0.620	2.447	1.903	0.320
YCA	0.552	0.409	0.629	2.568	1.971	0.320
YCB	0.796	0.824	0.623	2.661	2.031	0.333
YCC	0.355	0.437	0.626	2.423	1.872	0.309
YCD	0.371	0.137	0.628	2.411	1.825	0.321
USYCA	0.912	0.281	0.638	2.584	1.936	0.324
USYCB	0.527	0.559	0.620	2.464	1.890	0.328
RTSE	0.890	0.080	0.613	2.384	1.802	0.319
RSP500	0.639	0.160	0.615	2.511	2.005	0.335
CC	0.171	0.327	0.665	2.721	2.145	0.338
FBSGDP	0.308	0.938	0.639	2.476	1.864	0.330
UPSGDP	0.616	0.648	0.619	2.553	1.948	0.343

Six-month forecast horizon

The leading economic index estimated with a forecast horizon of six months (LEI-6) includes five variables in addition to the coincident economic index: the help wanted index, the short-term yield curve, the long-term yield curve, the real TSE 300 stock market index and the federal balance as a share of GDP. The calculations resulted in a model with twelve lags on the short-term yield curve, six lags on the long-term yield curve, three lags on the CEI and nine lags on the remaining variables. The six-month growth rate in the CEI and the LEI-6 are plotted in Figure 3.2, which also provides a description of the model and the key statistics related to its forecast performance. The statistics show that the fit of the six-month ahead regression (0.677) is better than that of the three-month ahead regression. The forecast errors are also smaller. Here again, the RMSE, the MAE, and the U-Theil coefficient suggest that the forecast of the six-month growth rate in the coincident index could not be improved anymore with additional variables as shown in Table 3.3 (page 18).

Figure 3.2 Six-month growth rate in the CEI and the LEI-6



The model:

$$\Delta C_t^{t+6} = \sum_{i=0}^{3} \beta_i \Delta C_{t-i} + \sum_{i=0}^{9} \delta_i^1 HWI_{t-i} + \sum_{i=0}^{12} \delta_i^2 YCE_{t-i} + \sum_{i=0}^{6} \delta_i^3 YCA_{t-i}$$

$$+ \sum_{i=0}^{9} \delta_i^4 RTSE_{t-i} + \sum_{i=0}^{9} \delta_i^5 FBSGDP_{t-i} + e_t$$

Full sample adjusted R^2: 0.677;

Out-of-sample RMSE: 2.218; MAE: 1.752; U-Theil: 0.297

Table 3.3 Effect of including additional variables in the LEI-6

	p-value					
Variables	**6 lags**	**12 lags**	**Adj. R^2**	**RMSE**	**MAE**	**U-Theil**
Base model	---	---	**0.677**	**2.218**	**1.752**	**0.297**
Additional variables:						
RBP	0.612	0.797	0.666	2.381	1.911	0.321
NRBP	0.782	0.228	0.709	2.452	1.929	0.316
CBLUS	0.884	0.385	0.667	2.349	1.875	0.316
FLUS	0.640	0.729	0.670	2.424	1.897	0.327
CBCEUS	0.442	0.737	0.681	2.367	1.923	0.309
OLUS	0.905	0.299	0.681	2.417	1.891	0.314
OLEU	0.917	0.555	0.676	2.507	1.975	0.332
NER	0.971	0.705	0.670	2.350	1.862	0.311
RER	0.997	0.865	0.670	2.363	1.900	0.320
FCPI	0.776	0.755	0.677	2.619	2.102	0.367
FRCPI	0.772	0.722	0.679	2.594	2.068	0.365
RM1	0.625	0.691	0.674	2.578	1.977	0.333
MCI	0.589	0.653	0.666	2.606	2.026	0.336
YCB	0.995	0.991	0.670	2.430	1.913	0.322
YCC	0.873	0.756	0.675	2.456	1.960	0.323
YCD	0.474	0.857	0.665	2.366	1.958	0.313
USYCA	0.891	0.219	0.694	2.324	1.851	0.304
USYCB	0.559	0.039	0.701	2.272	1.815	0.312
RSP500	0.453	0.906	0.678	2.485	1.966	0.325
CC	0.025	0.054	0.733	2.326	1.820	0.305
UPSGDP	0.961	0.457	0.672	2.374	1.887	0.314

4. RECESSION INDEX

4.1 Definition and procedure

The Recession Index developed by Stock and Watson (1989) is computed as the probability that, six months hence, the time path of the coincident economic index will fall in a recession.[10] These probabilities are evaluated by numerical integration over the recession regions, using the four coincident variables and seven leading variables. The parameters[11] were chosen to minimize the sum of squared errors between the six-step ahead recession probability and the 0/1 recession variable six months hence.

We choose a simpler approach partly based on Stock and Watson (1991). Our Recession Index is a forecast three- and six-month ahead of the recession path in the CEI using a logit model. We use the cycle chronology obtained from the application of the two-states Markov-switching models on the growth rate of the CEI (see section 2) to define the recession path. We then construct the variable R_{t+k}, where $R_t = 1$ if the economy is in a "CEI-dated recession" in month t and $R_t = 0$ if it is not.[12]

The approach taken here is to estimate several binary logit models using R_{t+k} as the dependant variable. For each horizon forecast (k = 3 and k = 6), we first estimate a base model with only the LEI-k as predictive variable. Next, we include contemporaneous values and three lags of individual leading variables. We then choose the best individual leading variable based on two criterions: the fit (R^2) of the regression of the forecast probabilities computed by the logit model on the actual (0/1) recession variable, and a measure of false signals based on Stock and Watson (1991). This latter criterion presents the number of months in which a recession is forecast when in fact no recession occurs k-

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10 They define a month to be in a recession if that month is either in a sequence of six consecutive declines of the CEI below some boundary, or in a sequence of nine declines below the boundary with no more that one increase during the middle seven months.

11 The parameters are the means and variances of the random boundaries.

12 We also estimated the logit models with R_{t+k} defined as a minimum of four consecutive months with an inferred probability greater than 50% and the results were relatively similar.

month ahead plus the number of months in which no recession is forecast when in fact a recession occurs *k*-month ahead. We choose the next leading variable to include in the logit equation with the same approach, using the LEI-*k* and the first best single leading variable in the base model. We do this until the performance cannot be improved anymore.

4.2 Results

We apply the procedure described above over the entire sample. The results for the three- and six-month forecast horizon are reported in Tables 4.1 and 4.2 respectively. The first noteworthy result is that the inclusion of the leading variables improves significantly the performance of both recession indexes. We can refer to Appendix B to see what happened graphically to the recession indexes when variables are added to the base case.

Three-month forecast horizon

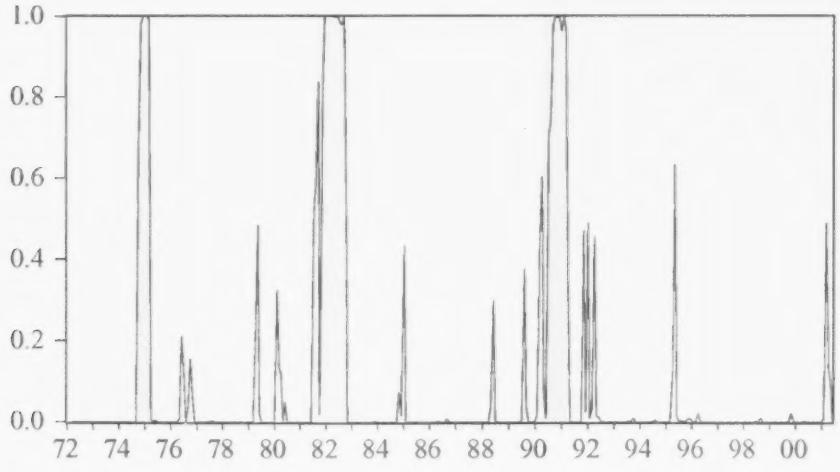
The best model to predict recessions three months ahead is model 8 in Table 4.1, which includes in the right-hand side of the logit equation: the LEI-3, contemporaneous values and three lags of the help wanted index, the Conference Board index of leading indicators for the US and the short-term yield curve. This model minimizes the number of false signals over the full sample. The three-month ahead recession index (out-of-sample from 1984.01) is plotted in Figure 4.1. We can see that the recession beginning in October 1974 is predicted three months before, in July 1974. Furthermore, the end of the recession, which occurred in March 1975, is anticipated in December 1974. The second CEI-dated recession that began in July 1981 is anticipated in April 1981. The first false signal of the recession index occurs in July 1981 when the probability decreased to 2%, suggesting that there was no recession three months after in October, which was not true. The remaining of the 1981-1982 recession, which lasted sixteen months, is anticipated. The start of the last recession is signalled in January 1990. However, two false signals occur in February and March as the probabilities of the recession index decreased to 8% and 1% respectively in those months. As for the previous recession, the remaining of the 1990-1991 recession is perfectly anticipated three months before. Finally, the probability

of the recession index reached 63% in February 1995, suggesting a recession begining in May when in fact no recession occurred.

Table 4.1 Performance of logit models in predicting the CEI-dated recessions at a three-month horizon

Series	Adj. R^2	False signals
1. Base model	0.618	15
2. HWI	0.752	11
3. YCE	0.638	11
4. CBLUS	0.642	14
5. NRBP	0.644	18
6. HWI, YCE	0.807	6
6. HWI, CBLUS	0.849	6
7. HWI, NRBP	0.790	9
8. HWI, CBLUS, YCE	**0.873**	**4**
9. HWI, CBLUS, NRBP	0.842	8
10. HWI, CBLUS, YCE, NRBP	0.886	8

Figure 4.1 The Recession Index – three-month ahead



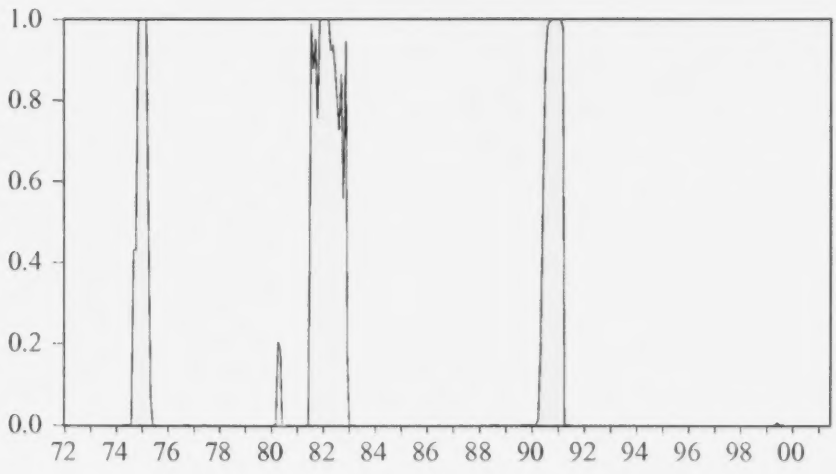
Six-month forecast horizon

The best model to predict recessions six months ahead is model 11 in Table 4.2, which includes in the right-hand side of the logit equation: the LEI-6, contemporaneous values and three lags of the long-term yield curve, the help wanted index and the short-term yield curve. This model also minimizes the number of false signals over the full sample. The six-month ahead recession index (out-of-sample from 1984.01) is plotted in Figure 4.2. We can see that it seems to fit very well the CEI-dated recessions. As in the case of the three-month ahead recession index, the six-month ahead recession index perfectly anticipates the start and the end of the 1974-1975 recession. The recession index, in January 1981, correctly anticipates the start of the July 1981-October 1982 recession, but misses the end of this recession by one month, as it projects the end in November 1982. The start of the April 1990-March 1991 is anticipated only four months ahead since the probabilities of the recession index in October and November 1989 are respectively 1% and 18%. However, in September 1990, the recession is anticipated to finish in March of the next year. Finally, the recession index perfectly forecasts the remaining of the period.

Table 4.2 **Performance of logit models in predicting the CEI-dated recessions at a six-month horizon**

Series	Adj. R^2	False signals
1. Base model	0.624	14
2. HWI	0.682	14
3. YCE	0.653	12
4. YCA	0.777	8
5. RTSE	0.629	16
6. FBSGDP	0.657	14
7. YCA, HWI	0.846	8
8. YCA, YCE	0.801	7
9. YCA, RTSE	0.788	10
10. YCA, FBSGDP	0.792	7
11. YCA, HWI, YCE	**0.900**	**3**
12. YCA, HWI, RTSE	0.909	4
13. YCA, HWI, FBSGDP	0.856	7
14. YCA, HWI, YCE, RTSE	0.892	4
15. YCA, HWI, YCE, FBSGDP	0.903	5

Figure 4.2 The Recession Index – six-month ahead



5. CONCLUSION

At the end of the 1980s, Stock and Watson developed a new system of composite indexes of coincident and leading economic indicators, as well as a recession index for the United States, using modern econometric techniques. This paper proposes monthly coincident and leading economic indexes for the Canadian economy built with the same methodology. We also propose a recession index, derived from the constructed leading index.

The main conclusions of the paper are the following:

- The new composite coincident economic index, which includes employment, manufacturing shipments, retail sales, housing starts and a coincident index of U.S. economic activity, tracks very well both the monthly and quarterly official measures of Canadian real GDP.

- The business cycle chronology derived from the coincident economic index closely matched the recession dates identified by Cross (1996).

- The coincident economic index predicted correctly 70 per cent of the time the sign of the first difference in monthly real GDP at basic prices. Because the coincident economic index is computed about two weeks before the official release of monthly real GDP, the coincident economic index could provide very useful information about the performance of the economy, notably when the likelihood of a cyclical turning point is high.

- The approach for the construction of a composite leading economic index is also different from the traditional indicator approach. Rather than constructing a composite index on the basis of a weighted average of leading indicators, we used, as did Stock and Watson, past changes in the coincident economic index as well as other variables that have historically led the business cycle to forecast the change in the coincident economic index. The paper proposed two leading economic indexes, which are forecasts of the coincident economic index. The first one is a three-month

ahead forecast of the coincident economic index. The second one is a six-month ahead forecast of the coincident economic index. The out-of-sample simulation revealed that both leading indexes are reliable forecasts of future economic activity three- and six-month ahead. Furthermore, both leading economic indexes predicted between 80per cent and 90 per cent of the time the correct sign of the first difference in the coincident economic index.

- Finally, the paper proposed a recession index that is a forecast probability that the economy will be in a recession in the coming three or six months. Our assessment of the performance of both recession indexes suggests that they performed well in forecasting recessions in the 1980s and 1990s.

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APPENDIX A

Identification of Lead/Lag Relationships of Potential Leading Indicators with the Business Cycle Using Markov-Switching Models

We employ two types of Markov-switching models to investigate the lead/lag relationships between potential leading indicators and our proposed coincident index.

First, we apply the standard Markov-switching model of Hamilton (1989) to each of the potential leading indicators to estimate the recession probabilities exhibited by this series. By comparing the recession probabilities of each indicator to those of the proposed coincident index, we can see whether the potential leading indicators lead the proposed coincident index.

However, this approach tells us neither how many periods a leading indicator leads the coincident index nor how significant the lead is. To address these issues, we apply a bivariate Markov-switching model of Hamilton and Perez-Quiros (1996) to each of the potential leading indicator and the proposed coincident index. In this model, the leading indicator and the coincident index share the state of the business cycle, but the leading indicator moves r periods before the coincident index. Let the unobserved state of the economy s_t takes value 0 when the economy is in contraction and 1 when the economy is in expansion, and the state is assumed to evolve according to a first order Markov chain. The leading indicator and the coincident index grow at the rates η_1 and μ_1 in expansion and at lower rates η_0 and μ_0 in contraction. If it were possible to observe the value of state s_t, then the expected growth rate for the coincident index conditional on knowing the state of business cycle would be

$$E(\Delta y_t \mid s_t) = \mu_{s_t},$$

However, the conditional expectation of the leading indicator growth Δx_t depends not on s_t but rather on s_{t+r}

$$E(\Delta x_t \mid s_{t+r}) = \eta_{s_{t+r}}$$

where $\eta_{s_{t+r}} = \eta_0$ when s_{t+r}=0, and $\eta_{s_{t+r}} = \eta_1$ when s_{t+r}=1.

Thus, the general form of this time-series model is

$$\Delta y_t = \mu_{s_t} + a(L)(\Delta y_{t-1} - \mu_{s_{t-1}}) + b(L)(\Delta x_{t-1} - \eta_{s_{t+r-1}}) + e_{1t},$$

$$\Delta x_t = \eta_{s_{t+r}} + c(L)(\Delta y_{t-1} - \mu_{s_{t-1}}) + d(L)(\Delta x_{t-1} - \eta_{s_{t+r-1}}) + e_{2t},$$

To estimate this model, the autoregressive order can be selected by Schwarz criterion, then the value of r producing the highest value for the likelihood is the periods the leading indicator leads the coincident index.

APPENDIX B

Table B.1 The variables used to construct CEI, LEI and the Recession Index

Coincident Economic Index	Leading Economic Index		Recession Index	
CEI	LEI-3	LEI-6	RI-3	RI-6
TE	CEI	CEI	LEI-3	LEI-6
MS	HWI	HWI	HWI	HWI
RS	YCE	YCE	YCE	YCE
HS	CBLUS	YCA	CBLUS	YCA
USCI	NRBP	RTSE		
		FBSGDP		

LEI-3	Constructed leading economic index-- three months ahead
LEI-6	Constructed leading economic index-- six months ahead
RI-3	Constructed recession index—three months ahead
RI-6	Constructed recession index—six months ahead
TE	Total employment
MS	Real manufacturing shipments
RS	Real retail sales
HS	Total housing starts
USCI	U.S. coincident economic index from the U.S. Conference Board
HWI	Help wanted index
NRBP	Non-residential building permits
CBLUS	U.S. leading economic index from U.S. Conference Board Canada
YCA	Yield curve – 10 year bond *minus* 3 month corporate paper
YCE	Yield curve – 3 month Treasury bills *minus* 3 month corporate paper
RTSE	Real TSE 300 aggregate index (deflated by total consumer price index)
FBSGDP	Federal balance as a share of GDP

Figure B.1 Effects of including leading variables in the logit equation at a three-month forecast horizon

In-sample: 1973M01 – 2001M06

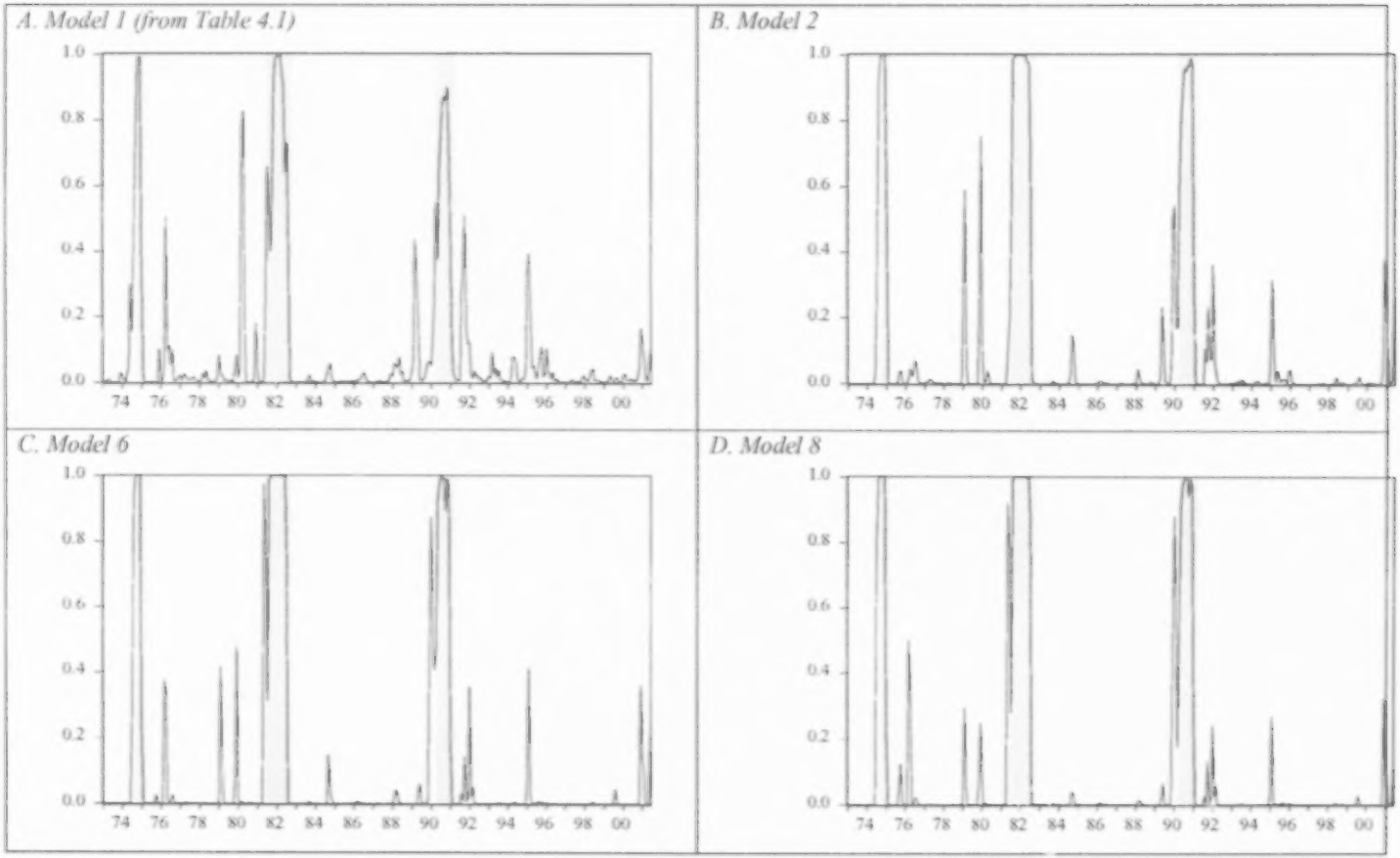

Figure B.2 Effects of including leading variables in the logit equation at a six-month forecast horizon

In-sample: 1973M01 – 2001M06